having been measured. No. 1, from the edge of the marsh, represents the most ancient period; No. 3, from the middle of the marsh, the most recent.

To sum up: First, all Michigan lakes are disappearing, not by drainage or evaporation altogether, but by being converted into bogs or marshes. Many shallow lakes are already closed in that manner; all others are closing. Second, deposits in those lakes do not succeed each other from the bottom upward, but from the sides centerward. A find resting on the clay four feet below the surface near the edge of a marsh or ancient lake may represent a time vastly anterior to a find similarly situated 20 feet below the surface near the center of the same marsh.

Another closing observation: Additions of growth in a marsh are not made entirely by horizontal deposits of foliage, but largely by perpendicular additions of grass roots throughout the extent of the newly forming marsh and by perpendicular additions of grass leaves overhanging the edge next the lake. Pressure is mostly horizontal and from the center of the lake toward its periphery by the swelling of the ice in the lake in winter. This aids in making the material constantly more compact after being once formed. It aids also in thickening the deposit by reducing the surface dimensions.

THE STRATIGRAPHY OF SHAWNEE COUNTY.

By J. W. BEEDE, Topeka, Kan. Read before the Academy January 4, 1896.

There are good exposures of the Upper Coal Measures, and especially of the highest Carboniferous coal-beds of workable thickness in the state, in Shawnee county. The best sections are the bluffs on the south side of the Kansas river. The first students of this section of Kansas geology were Meek and Hayden in 1858, and Prof. G. C. Swallow in 1865. Prof. O. St. John published the results of his work in 1881 and 1882. Later Prof. Charles S. Prosser and Prof. E. Haworth contributed to the knowledge of the region.

GENERAL DESCRIPTION.

There are about 550 feet of the Upper Coal Measures strata exposed, ranging from about 1,875 to 2,425 feet above the base of the Coal Measures.* The strata are a succession of limestones, shales, and coal. They dip to the west about 10 feet to the mile. There are no faults or folds of any consequence. The highest stratum of coal found in paying quantity in the eastern half of the state traverses the county in a northerly direction, passing through the central part.

The topography is comparatively simple. The Kansas river crosses the county from west to east, with a broad valley situated largely on the north side of the river. North of the river bottom is a rolling prairie, which rises to an elevation of about 1,100 feet A. T. at the north line of the county. A prairie extends from the south bluff of the river to a high divide, which traverses the county a little south of west, being intercepted for a few miles near Pauline. This divide reaches its highest point in the southwest corner of the county, where it is 1,200 feet A. T.† In the southern part of the county lies the broad valley of Wakarusa creek, which is nearly as low as the river bottom itself. Three heavy limestone systems give the more rugged topography to the county.

While we do not enter into the discussion of the subject in this paper, it may

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*See Prof. E. Haworth, Kan. Univ. Quar., Vol. III, No. 4, April, 1895.

†U. S. topographic sheets.

be well to mention a few facts concerning the glacial geology of the county. Although the general trend of the terminal moraine is northwest and southeast, this is but very roughly true of the part which lies in Shawnee county. Entering the county a little north of Richland, it extends in a northwesterly direction towards Topeka, passes around the north side of Burnett's Mound (three miles southwest of Topeka), thence a little westward, where it bears to the southward to within a mile of Dover and crosses the west line of the county. The break in the divide at Pauline, which is fully a hundred feet in depth at that place, formed an outlet to the water at the foot of the glacier.*

Historical.

Meek and Hayden.—In 1858, Messrs. Messrs. F. B. Meek and F. V. Hayden crossed Shawnee county on their "Geological Explorations in Kansas Territory." † In this preliminary tour, one or possibly two sections were made in this county. The most important section was made near the old Baptist Mission. Here a section of 164 feet is given in detail. The place was probably near the place where the Topeka sugar works are now situated. The other section was one of 12 feet, somewhere southwest of Grasshopper creek.

Swallow.—Later Prof. G. C. Swallow, in his "Section of the Rocks of Eastern Kansas," ‡ gives a section of the rocks of eastern Kansas which crosses Shawnee county from west to east. The structure is given in detail, but contains several errors. He gives 32 strata, which are probably supposed to be contained within the county. This includes sandstone and shale strata, which change from one to the other, and can hardly be separated with any degree of distinctness.

St. John.—Prof. O. St. John, in his article on the "Geology of Kansas," § gives a clear description of the Kansas Coal Measures and correlates the Topeka coal with that of Burlingame and Osage City.

Prosser.—Prof. Charles S. Prosser has recently done some work for the U. S. Geological Survey which extends into the county and is of considerable interest. He divides the upper part of the Upper Coal Measures ‖ and Permian of eastern Kansas into formations, the lowest of which is the "Wabaunsee." The shale overlying the Osage City coal is the base of this formation.

Haworth.—In an article entitled "The Stratigraphy of the Kansas Coal Measures," ¶ Prof. E. Haworth gives the stratigraphy of the state in ascending order. Shawnee county is included in the section, and consequently its strata are correlated with those of the rest of the state.

Stratigraphy.

1. Tecumseh Shales.** —Beginning at the east line of the county and taking the strata in ascending order, is a series of shales of about 75 feet in thickness found east of Tecumseh and in the vicinity of Richland. These shales are nearly non-fossiliferous, of fine texture, containing many ferruginous concretions, and occasional strata of soft, shaly sandstone. They are somewhat of an olive color.

2. Calhoun Limestone.—Three strata of limestone, bluish to yellowish gray

* Mr. B. B. Smyth discusses this subject in Vol. XIV, Transactions of this Academy, pp. 220-226.

† Proc. Acad. Nat. Sci., Phila., 1859, pp. 8-30.

‡ Prelim. Rep. Geol. Sur. Kan., 1868, pp. 1-28.

§ Third Biennial Rep. State Board Agriculture, Kansas, 1881-'82, pp. 571-579.

‖ Bull. Geol. Soc. Am., Vol. VI, pp. 29-54; also, Jour. Geol., Vol. III, pp. 682-705, 764-800.

¶ Kan. Univ. Quar., Vol. III, No. 4, April 1, 1895.

** These names are simply local references to the particular strata for convenience of students in this county, and no other importance should be attached to them.

in color, separated by layers of shale. The total thickness is 15 to 20 feet. The principal stratum is the uppermost, which varies from 7 to 10 feet in thickness. It is a massive limestone, in color light gray tinged with yellow. The texture may vary considerably in a short distance. The typical exposures are at Calhoun Bluffs, about three miles northeast of Topeka, where the Union Pacific railroad cuts the bluff of the Kansas river, and just east of Tevis, and on the bluffs north of Richland. It also appears on Muddy creek. It is hard and quite fossiliferous. It has been quarried for paving stone, the quarry being situated north of the road where Sixth street crosses Deer creek.

3. CALHOUN SANDSTONE AND SHALE.—This stratum is 50 to 65 feet in thickness. The lower part of the stratum is a layer of soft, argillaceous sandstone from 12 to 20 feet thick. This is perhaps the most persistent sandstone in the county. The shale is of bluish tint and comparatively fine texture. The location of this stratum is the same as the preceding, except that it ranges a trifle further west.

4. TOPEKA LIMESTONE (Haworth).*—This system of limestone is 10 to 15 feet in thickness, according to the thickness of the clay partings, composed of four strata separated by partings of clay-like shale. This system forms a marked feature in the topography of the eastern part of the county. Typical exposure at the county quarry in the fair grounds, at Topeka; but here only the three lower strata are exposed. It rises in a southeasterly direction to the east line of the county, forming the tops of the high hills southeast of Tecumseh. It is exposed at Wakarusa station, and forms the top of the escarpment at Calhoun Bluffs. This limestone has been quarried more than any other in the county, and is used to a considerable extent for building purposes. It is a light buff in color, except the lowest layer, which is of a bluish gray tint. It contains considerable chert.

5. OSAGE CITY SHALES (Haworth).*—This is a stratum of bluish varying to a yellowish shale, 50 feet in thickness, very argillaceous and nearly barren of fossils. Typical exposure, Topeka vitrified brick works, one-half mile west of insane asylum. It is the shale used by the above company in the manufacture of the walk and paving brick in Topeka. The brick is of very high grade of hardness, and is the finest produced in this country for paving purposes.

6. OSAGE COAL.—This coal is variously called the "Osage," "Burlingame," "Scranton," "Carbondale," "Topeka," etc., coal. It is correlated by Professor St. John† as the Osage Coal. It is a stratum of bituminous coal from 6 to 20 inches in thickness. It is mined three miles southwest of Topeka and from Martin's hill to within a mile and a half of Washburn College, and also at Burnett's mound. It appears near Pauline, where it is about six inches thick; while on Wakarusa creek, west of Wakarusa station, it seems to be entirely wanting, or the shale above it thickened to four or five times its usual thickness in this county. On the north side of the Kansas river it is to be found on the Halfday and Indian creeks and also near Meriden and Valley Falls.

7. SHUNGANUNGA SHALE.—Base of the "Wabaunsee" formation of Professor Prosser. This stratum of shale varies from 10 inches to 10 feet in thickness and in color from a dark olive to a bluish and even jet black. It is very fossiliferous in places. Localities same as previous stratum. Eastern extremity of this formation indicated on the plate by the line between the shaded and unshaded portions. The shaded portion is the Wabaunsee formation.

*These names are simply local references to the particular strata for convenience of students in this county, and no other importance should be attached to them.

† Ibid. See, also, Univ. Geol. Surv. Kan., Vol. I, p. 161, and foot-note.

‡ Third Biennial Report Kansas State Board Agriculture, 1881-'82, p. 585.

8. Spring Rock (Swallow).*—Here we have two strata of limestone separated by a layer of shale. Of these the lower is the more important, the upper being as a rule very thin and somewhat argillaceous. The lower is about 20 inches thick, hard, bluish gray in color, often containing calcite crystals, and is susceptible of a high polish. It has been quarried for paving purposes, and is the hardest limestone in the county. This stratum has, so far, produced a larger number of species of fossils than any other stratum in the county. Localities same as two previous strata.

9. Burlingame Shales (Haworth).†—Olive shales, generally very argillaceous, though arenaceous in places, 120 feet thick, and the most extensive shale bed in the county. The stratum is very fossiliferous in places, and barren of fossils in others. It is exposed at the Sugar Works, on the lower part of Blacksmith and Mission creeks, southeast of Auburn on Wakarusa creek, on the north side of the river from near Siver Lake, crossing the county in a direction east of north.

10. Silver Lake Coal.—A bituminous coal 4 to 16 inches thick. This is the highest stratum of coal found in paying quantity in the Coal Measures in the state. It is mined at the Croasdale place, 10 miles southwest of Topeka, and has been mined at the Sugar Works, Silver Lake (Pence's farm), and some further northeast, and is reported from the Pottawatomie reservation, and northwest of Meriden.

11. Silver Lake Shale.—This shale, which is olive in color and not very rich in fossils, is 15 to 35 feet in thickness, and contains a thin, very argillaceous limestone.

12. Stanton Limestone (Swallow).‡—This limestone is composed of two layers, separated by a thin parting of shale. The lower is the more important. It is from four to seven feet in thickness, massive, yellowish gray to gray, and almost non-fossiliferous. It resists the weather very well, and is easily traced across the county, as it often forms the top of high escarpments. It is exposed on Wakarusa creek, near Auburn; on Mission creek, from a place west of Burnett's mound to the Kansas river; at Burnett's mound, Martin's hill, and the sugar works; from Silver Lake up Big and Little Soldier creeks about three miles, thence in an easterly direction. It appears at Elmont and crosses the county line nearly north of that place.

13. Soldier Creek Shale.—This shale is from 40 feet to less in thickness, quite arenaceous, and moderately fossiliferous in places. Localities same as the preceding.

14. Wakarusa Limestone.—A limestone two to four feet in thickness, very fossilferous, and a fine building stone. Localities practically the same as the two preceding. Named from the fine exposure of this rock on Wakarusa creek immediately south of Auburn.

15. Auburn Shale.—This is a stratum of shale 8 to 20 feet in thickness, olive in color, and quite fossiliferous. Localities practically the same as the preceding.

16. Elmont Limestone.—A stratum of white or gray argillaceous limestone, very fossiliferous, from one to two feet in thickness. It is used in stone walls in some places. It is found on the tops of the hills near Elmont and north into Jackson county; also on both sides of Big and Little Soldier creeks, from the

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*Prelim. Rep. Geol. Surv. Kan., 1868, p. 21, "No. 162."
†Univ. Geol. Surv. Kan., Vol. I, p. 162.
‡Prelim. Rep. Geol. Surv. Kan., 1868, p. 20.

Kansas river up Blacksmith and Mission creeks two thirds the way to Dover, and at Auburn.

17. WILLARD SHALE.—This shale is 55 feet thick, and is exposed down Big and Little Soldier creeks from Jackson county to the Kansas river, and from the Kansas river to Dover; also southwest of Auburn and southwest of Burnett's Mound.

18. CHOCOLATE LIMESTONE (Swallow).*—A limestone 7 to 10 feet thick, chocolate brown, sometimes lighter, and containing great quantities of *Fusilina cylindrica* Fischer. This is the most easily recognized limestone in the county, often forming escarpments 50 to 100 feet high. It withstands weathering remarkably well, and is used quite extensively for stone walls. It would probably prove valuable as a building stone. It appears on the top of the hill at Auburn and to the southwest; also from Dover to the Kansas river, and from the Kansas river up the two Soldier creeks to Jackson county. It also appears along the base of the hills that border the Kansas bottom a few miles west of Rossville.

19. DOVER SHALE AND SANDSTONE.—This shale is 85 feet in thickness, very arenaceous in texture, varying in color from a light yellow to a deep brownish red, containing much argillaceous sandstone which is exposed on the road east of Dover. It is nearly non-fossiliferous. It appears near Dover and southwest, and in the northwest part of the county.

20. DOVER LIMESTONE.—This limestone is four feet to less in thickness, appearing near Dover and to the southwest, and in the northwestern portion of the county.

21. ROSSVILLE SHALES AND SANDSTONE.—About 100 feet of shales and sandstones (soft) of various colors, nearly non-fossiliferous; contains occasional streaks of limestone. Localities as before.

PALEONTOLOGY.

Following is a list of the fossils of the county so far as known. The numerals represent the strata in which they are found as numbered in the text. Doubtful species are queried (?). Liberal allowance must be made for lack of literature in determination.

Lophophyllum proliferum, McChes. 2, 4, 7, 8, 18.
Undetermined, 2.
Archæocidaris agassizi, Gein. 2, 4, 8.
Campophyllum torquium, Owen, 8.
Delocrinus hemisphericus, (——), 7 (S. A. Miller's identity).
Fenestella limitaris, Ulr. ? 4*, 8*.
Fenestella sevillensis, Ulr. 4*, 8*.
Fenestella compressa, Ulr. 4*, 8*.
Fenestella modesta, Ulr. ?? 4*, 8*.
Polypora spiniodata, Ulr. ? 4*, 8*.
Rhombopora varius, Ulr. 4*, 8*.
Rhombopora lepidodendroides, Meek, 4.
Synocladia biserialis, Swall. 4.
Streblopora nicklesi, Ulr. 4*, 8*.
Stenopora carbonaria, Ulr. 4*, 8*.
Stenopora carbonaria var. conferta, Ulr. ? 4*, 8*.

* Prelim. Rep. Geol. Surv. Kan., 1868, p. 19. Geographical names have been applied as far as possible to all strata; but this name and that of the "Spring Rock" are quite appropriate and not liable to be confused with anything else in this section, and hence they are left.

Blatostomella interstincta, Ulr. 4, 8*.
Productus cora, d'Orb. 2, 4, 7, 8, 14, 16, 18, 21.
Productus costatus, Sow. 4, 7, 8.
Productus longispinus, Sow. 2, 4, 7, 8, 14, 16.
Productus nebrascensis, Owen, 2, 4, 7, 8, 12, 16, 18.
Productus punctatus, Mart. 2, 4, 8, 16.
Productus semireticulatus, Meek, 4, 7, 8, 14, 16.
Productus symmetricus, McChes. 6, 7.
Productus pertenuis, Meek, 2, 4, 7, 8.
Productus undetermined, 7.
Undetermined, 14.
Chonetes granulifera, Owen, 2, 4, 7, 8, 11, 12, 14, 15, 16, 18.
Chonetes? undetermined, 16.
Chonetes glabra, Hall, 7, 8.
Spirifer cameratus, (Hall) Meek, 2, 4, 7, 8, 14, 16.
Spirifer lineatus, Mart. 2, 4.
Spirifer planoconvexus, Shum. 2, 4, 7, 8.
Spiriferina kentuckiensis, Shum. 2, 4, 7, 8.
Rhynconella uta, Marcou, 2, 7.
Rhynconella undetermined, 8.
Discina nitida, Phill. 4, 7, 9.
Discina convexa, Shum. 7, 8.
Lingula mytiloides, Sow. 7, 9.
Lingula umbonata, Cox, 7.
Athyris subtilita, Hall, 2, 4, 7, 8, 11, 12, 14, 16, 18, 21.
Retzia mormonii, Marcou, 4, 7, 8, 11, 14.
Derbya crassa, (Phill.) H. & C. 2, 4, 7, 8, 14.
Derbya robusta, H. & C. 2, 4, 8, 14.
Meekella striocostata, Cox, 2, 14, 18.
Undetermined, 18.
Terebratula bovidens, Mort. 2, 4, 8, 12.
Syntrielasma hemiplicata, (Hall) M. & W. 2, 8, 16, 18.
Undetermined, 16.
Myalina undetermined, 9.
Myalina? undetermined, 7.
Myalina perattenuata, M. & H. 7, 14.
Myalina recurvirostris, M. & W. 2, 14.
Myalina subquadrata, Shum. 2, 14.
Myalina swallovi, McChes. 2, 4, 7, 8, 9, 21.
Allorisma costata, M. & W. 16.
Allorisma geinitzii, Meek?, 16.
Allorisma granosa, (Shum.) Meek, 2, 4, 7, 8, 9, 14, 16.
Allorisma subcuneata, M. & H. 2, 4, 8, 16.
Allorisma winchellii, Meek??, 7, 9.
Allorisma undetermined, 4, 8, 16.
Yoldia undetermined, 16.
Pseudomonotis hawni, M. & H. 21.
Monoptera marian, White, 4, 8.
Monoptera? undetermined, 21.

*The bryozoa from strata numbers 4 and 8 were accidentally mixed, and it is impossible to tell from which the various specimens came, but they are from one or the other, while some are from both.

Undetermined, 8.
Aviculopecten coxanus, M. & W. 7, 8.
Aviculopecten carboniferus, Stev. 7, 8.
Aviculopecten hertzeri, Meek, 8.
Aviculopecten cf. lyellii, Daws. 8.
Aviculopecten mccoyi, M. & H. 8.
Aviculopecten neglectus, (—), 8.
Aviculopecten occidentalis, Shum. 2, 7, 9, 14, 16, 21.
Aviculopecten winchellii, Meek??, 4, 7.
Aviculopecten whitei, Meek??, 3, 7, 9.
Aviculopecten undetermined, 2, 4.
Nuculana bellistriata, Stev. 7, 9, 16.
Nuculana bellistriata, var. attenuata, Meek, 7, 8, 9.
Solenomya radiata, M. & W. 7.
Solenomya? undetermined, 8.
Entolium aviculatum, (Swall.) Meek, 2, 4, 7, 8, 14, 16.
Schizodus curtus, M. & W. 4, 7, 16.
Schizodus curtiforme, Walcott, 4, 8, 16.
Schizodus rossicus, De Verne, 4, 8.
Avicula longa, (Gein.) Meek, 7.
Lima retifera, Shum. 7, 8.
Nucula ventricosa, Hall, 7, 9.
Pinna peracuta, Shum. 2, 4, 7, 8, 11, 16.
Pinna subspatulata, Worthen, 2.
Macrodon tenuistriata, M. & W. 4, 8, 16.
Macrodon undetermined, 4.
Prothyris elegans, Meek, 7.
Aviculopinna americana, Meek, 8.
Undetermined, 7.
Dentalium meekianum, Gein. 18, 20.
Machrocheilus intercalaris, M. & W. 16.
Machrocheilus angoliferus, White, 7.
Machrocheilus ventricosus, Meek, 7.
Machrocheilus primigenius, (Con.) Hall, 8.
Machrocheilus undetermined, 14.
Loxonema undetermined, 8.
Cf. Murchisonia marcouiana, Gein. 4.
Aclis swallovina, (Gein.) Meek, 4.
Euomphalus subrugosus, Hall, 7, 8, 9, 16.
Anomphalus rotulus, M. & W. 7.
Bellerophon bellus, Keyes, 7.
Bellerophon percarinatus, Con. 7, 14.
Bellerophon carbonarius, Cox, 4, 8, 11, 14.
Bellerophon textilis, Hall, 16.
Bellerophon montfortianus, N. & P.? 15, 16.
Bellerophon undetermined, 8.
Orthonema sublæniatum, Gein. 7.
Naticopsis nana, M. & W. 7.
Naticopsis ventricosa, (N. & P.) M. & W. 7, 8.
Naticopsis wheeleri, Swall.? 2.
Naticopsis altonensis, McChes. 8.
Pleurotomaria grayvillensis, N. & P. 7.

Pleurotomaria illinoiensis, Worthen, 7.
Pleurotomaria perhumerosa, Meek, 7.
Pleurotomaria sphærulata, Con. 7, 14.
Pleurotomaria subdecussata, Gein. 7, 11.
Pleurotomaria tabulata, Hall, 2, 8.
Nautilus occidentalis, Swall. 8, 14.
Orthoceras undetermined, 4.
Orthoceras undetermined, 14, 16.
Orthoceras cribosum, Gein. 7, 8.
Cythere? undetermined, 9.
Phillipsia major, Shum.? 2, 4.
Phillipsia scitula, M. & W. 2, 4, 7, 8.
Nautilus cf. ponderosus, White, 8.
Nautilus cf. planovolvis, Shum. 8.
Peripristis semicircularis, Newb. & Worthen, 4, 8.
Petalodus destructor, Newb. & Worthen, 2, 4, 8.
Fossil worm?? 1.
Fossil worm, 1.

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